Hetch Hetchy:
striking a balance

A review of the Department of the Interior's Survey of Water & Power Replacement Concepts for Hetch Hetchy

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In July 1987, the Department of the Interior (DOI) advanced the idea of restoring the Hetch Hetchy Valley in Yosemite National Park to a more natural state. The Hetch Hetchy Valley was renowned for its scenic beauty, but since 1923 it has served as the reservoir for the water impounded behind the O'Shaughnessy Dam on the Tuolumne River. In order for the Hetch Hetchy Valley to be reclaimed as an addition to Yosemite National Park, the Hetch Hetchy Reservoir would have to be drained and the O'Shaughnessy Dam dismantled.

The Department of Energy (DOE) has reviewed the Hetch Hetchy restoration concept and has concluded that it is not viable at this time. Significant power and water storage capability would be lost. Environmental impacts during and after restoration would be significant. Moreover, the economic costs associated with replacement power and water storage options, as well as the cost of restoration, would be high. DOE recommends further study of the restoration of Hetch Hetchy Valley be deferred until O'Shaughnessy Dam approaches the end of its useful life.

Background

Hetch Hetchy Reservoir contains 360,360 acre-feet of storage. It is about 8 miles long and covers 1,972 acres within the Hetch Hetchy Valley. It and the smaller Lakes Eleanor and Lloyd, three hydroelectric generation plants, and various water conveyance systems and intakes form the Hetch Hetchy System (System). The System is owned and operated by the City and County of San Francisco to provide water and power for San Francisco, the Modesto and Turlock Irrigation Districts, and other Bay Area entities.

The System was authorized by Congress in 1913 via the Raker Act. The Act, as amended, granted San Francisco the right to develop water and power resources within the boundaries of the Yosemite National Park, subject to certain stipulations and limitations.

The System has the potential to provide up to 448,000 acre-feet per year of exceptionally high quality water with certain modifications to the conveyance system. Present maximum capacity is about 336,000 acre-feet per year, and the current average yield is about 214,000 acre-feet per year. Power generation at the three powerhouses totals 368 megawatts (MW) of capacity, 260 MW of which is considered dependable firm capacity. Average annual energy generation is 1,965 million kilowatthours (kWh). This power is valued at approximately $76 million.

The DOI Report

In November 1987, the DOI's National Park Service (NPS) issued a draft report entitled Hetch Hetchy: A Survey of Water and Power Replacement Concepts. The report sets forth the idea of restoring the Hetch Hetchy Valley, summarizes the Hetch Hetchy System, attempts to generally define the potential effects of implementing the concept, and identifies potential options for replacing the water and power resources. It concludes that the concept has sufficient merit to warrant further study, and that a 6-year, $5 million feasibility study be undertaken.

Replacing the Hetch Hetchy's water and power resources is necessary for the restoration concept to be viable. DOI's report identifies 11 potential replacement options. The first 3 options examine methods of "reoperating" the remaining System facilities. Significant impacts to power production could occur, however, as the system would be operated to maximize water yields. The New Don Pedro Reservoir, a non-Hetch Hetchy System facility downstream on the Tuolumne River, would be included in the "reoperation" plan.

Options 4 through 10 include "optimization-coordination-conjunctive use" alternatives and development of new water supplies from the Sacramento-San Joaquin Basin. Most of these options would entail new construction, with the associated economic costs and environmental impacts. Such options would also be net energy consumers, thus aggravating the power loss situation.

The last option suggests the purchase of surplus power to replace the loss of Hetch Hetchy energy.

Issues and Concerns

Issues and concerns are summarized by category below:

A. Power Issues

1. At least 150 MW of capacity would be lost permanently.

2. Approximately 900 million kWh of energy would be lost annually.

3. Many of the water replacement options would be net energy consumers, primarily due to water pumping requirements.

4. A replacement powerplant would be required when California's present electric generation capacity becomes fully utilized (year 2000 or later).

B. Water Issues

1. The loss of Hetch Hetchy Reservoir would eliminate about 300,000 acre-feet of San Francisco's present high quality water supplies.

2. Reoperation of remaining Hetch Hetchy System facilities and New Don Pedro may be able to meet most of the potential present water yield. However, water quality would be lower.

3. Dismantling O'Shaughnessy Dam would remove 360,360 acre-feet of water storage capability at a time when water use in California is predicted to increase by 1.4 million acre-feet over the next 25 years.

C. Environmental Issues

1. The environmental benefits of the existing reservoir, including loss of the water resource, scenic values, and reservoir fishery, would be affected.

2. The environmental benefits of restoring Hetch Hetchy Valley would displace the environmental benefits derived from the existence of the reservoir.

3. Only about 3 percent of park visitors visit Hetch Hetchy Reservoir (about 93,400 people in 1986), and the NPS has not indicated any plans to improve access to Hetch Hetchy Valley should it be restored.

4. There would be significant negative impacts to the environment during the time the drained reservoir was being revegetated and reclaimed.

5. The removal of O'Shaughnessy Dam would create serious environmental impacts at the dam site itself and at the disposal site or sites. Breaching or bypassing the dam while leaving it in place would minimize these impacts, but would defeat the stated goal and primary benefit of restoring the area to a wilderness condition.

6. All of the replacement options have associated environmental costs, many potentially significant. The options could involve the construction of new storage, enlargement of existing reservoirs, new conveyance systems, pumping stations, relocation of power generation facilities, and other major construction.

7. Kayaking and white-water rafting would probably be adversely impacted through changes in streamflows.

8. Erosion and siltation into the river could increase as a result of reservoir draining.

9. The DOI report recognizes significant legal problems with the transfer of existing water rights. Also, O'Shaughnessy Dam may be eligible for inclusion on the National Register of Historic Places.

10. Environmental effects associated with the eventual replacement of at least 150 MW of electric generation capacity will be high.

D. Economic Issues

1. Primary benefits derived from a restored Hetch Hetchy Valley will be intangible in nature.

2. Lost power (capacity and energy) generation is estimated to initially cost $80 million annually if replaced by a comparable thermal generating unit.

3. Future replacement of water and power supplies will likely be more costly than at today's prices.

4. Economic costs would be associated with all of the replacement options. Based on only a cursory examination, some would be prohibitively expensive. Exact figures for these options are not available, although estimates made by others, as reported in newspaper articles, have put the costs of a total replacement project between $2 and 6 billion.

5. Removal of O'Shaughnessy Dam and restoration of the Hetch Hetchy Valley will have a very high cost, given the size and and nature of the job.

Conclusions and Recommendation

The concept of reclaiming Hetch Hetchy Valley is not viable at this time. The economic and environmental costs are exceptionally high for a project without tangible economic benefits to offset them. Power losses are substantial. Water losses are also significant in terms of volume and quality with no assurance of a feasible means to replace the quality or quantity. Reregulation of the remaining System facilities will presumably be able to capture up to 336,000 acre-feet, but only with additional construction. The existing System can develop 448,000 acre-feet. Additional water treatment of these replacement supplies would be necessary, and even then would not likely match the existing quality.

The Hetch Hetchy Valley itself would be adversely impacted by the draining of the reservoir. Existing recreational and aesthetic values associated with the reservoir would be lost, but converted in time to

different values. During the revegetation and reclamation period, environmental values would be negatively affected. Removal of the dam would create high impacts, both on site and at the disposal area or areas. Bypassing or breeching the dam while leaving it in place would avoid these impacts, but would greatly negate the wilderness values the concept seeks to reclaim. Implementing the replacement options would spread additional impacts away from Hetch Hetchy Valley.

Economically, virtually all figures are in the cost column. The existing System has been in place for many years, with most construction costs amortized, and is relatively inexpensive to operate and maintain. Implementing the concept would not only be costly in terms of dam removal and reclamation of the damsite and the former reservoir, but also in terms of providing replacements for the water and power resources that would be lost. Although no reliable estimates are available, the total cost could easily be in the billions of dollars.

DOE recommends that a feasibility study of the Hetch Hetchy restoration concept not be pursued at this time. Data presently available clearly show very high economic and environmental costs associated with the idea, offset by only intangible benefits derived from the restored valley.

However, as O'Shaughnessy Dam moves closer to the end of its useful life (typical design life is 100 years), many of the negative economic and environmental impacts associated with the concept are reduced. Replacement water and power sources should already be under development by San Francisco and the irrigation districts in anticipation of the shutdown of Hetch Hetchy. The environmental and economic costs incurred in decommissioning the dam would be necessary, instead of optional, at that time and would not have to be assessed against the benefits of restoring the valley. Advances in technology may greatly affect the situation as it would exist at that future time.

Present information suggests that a cost/benefit analysis of the concept closer to the end of Hetch Hetchy's useful life would be a much more favorable time to revisit the restoration idea. An estimate as to when that point in time might occur could perhaps be determined by a thorough inspection of O'Shaughnessy Dam and a preliminary reservoir sediment survey.

I. INTRODUCTION

In July 1987, the Secretary of the Interior advanced the idea of creating a "second Yosemite Valley" within the Yosemite National Park. It was proposed that this be accomplished by draining the Hetch Hetchy Reservoir, dismantling and removing O'Shaughnessy Dam, and reclaiming the Hetch Hetchy Valley. Reaction to the plan was swift, but mixed. Conservation groups, such as the Sierra Club, found merit in the idea, but expressed reservations concerning the motivation behind the concept. The city of San Francisco, owner/operator of the Hetch Hetchy System and primary beneficiary of the water and hydropower, immediately and adamantly opposed the idea. The Modesto and Turlock Irrigation Districts also expressed opposition, based on potentially negative impacts on their rights to Hetch Hetchy System resources. (See Appendix 1.)

Amid much public debate and political interest, the Bureau of Reclamation prepared a draft report on the concept for the NPS entitled Hetch Hetchy: A Survey of Water and Power Replacement Concepts. The draft report, dated November 1987, analyzes the potential impacts on Hetch Hetchy water and power resources of implementing this idea and identifies 11 potential options for replacing these lost resources.

Ten of the options address the replacement of water supplies through "reoperation" of the remaining Hetch Hetchy facilities, potential offstream storage, expansion of existing storage, development of new supplies from other river systems, and various "optimization-coordination-conjunctive use" schemes. The eleventh option concerns power replacement through the purchase of surplus power from other sources. The report recognizes that these water and power resources must be replaced for the idea to be viable.

The report concludes that the Hetch Hetchy reclamation concept has some merit and that potential resources exist that can be utilized to replace the water and power supplies that would be lost. The overall feasibility of the concept with regard to impacts and costs was not determined in the draft DOI report. Rather, the report proposes that a 6-year, $5 million feasibility study be initiated to gather additional information and further refine the replacement options.

The NPS made the report available to its Advisory Board. DOI has indicated it is seeking input from individuals, organizations, and agencies having an interest in the idea.

DOE has conducted a preliminary analysis of the DOI report and the general concept of restoring the Hetch Hetchy Valley. The analysis contained in this document examines the concept from the perspectives of water issues, power issues, environmental considerations, and economic ramifications.

II. BACKGROUND

A. Hetch Hetchy System

1. History of Development

The city of San Francisco was assigned water rights on the Tuolumne River and two tributaries, Eleanor and Cherry Creeks, in 1903. The city was expanding and needed a dependable water supply in excess of its previously developed resources. Sites for water storage were identified along the Tuolumne and its tributaries. Development of these sites promised high quality water, good storage potential, gravity conveyance to the city, and the potential for hydroelectric power generation.

The Federal Raker Act of 1913 established the provisions under which San Francisco developed its water rights. The Act granted the city the authority to construct and operate storage reservoirs and hydroelectric facilities in the Hetch Hetchy, Eleanor, and Cherry Valleys, and in the canyon of the Tuolumne downstream from these locations. The Act further defined the city's obligations to the Modesto and Turlock Irrigation Districts and placed limitations on the city's authority to export and distribute water.

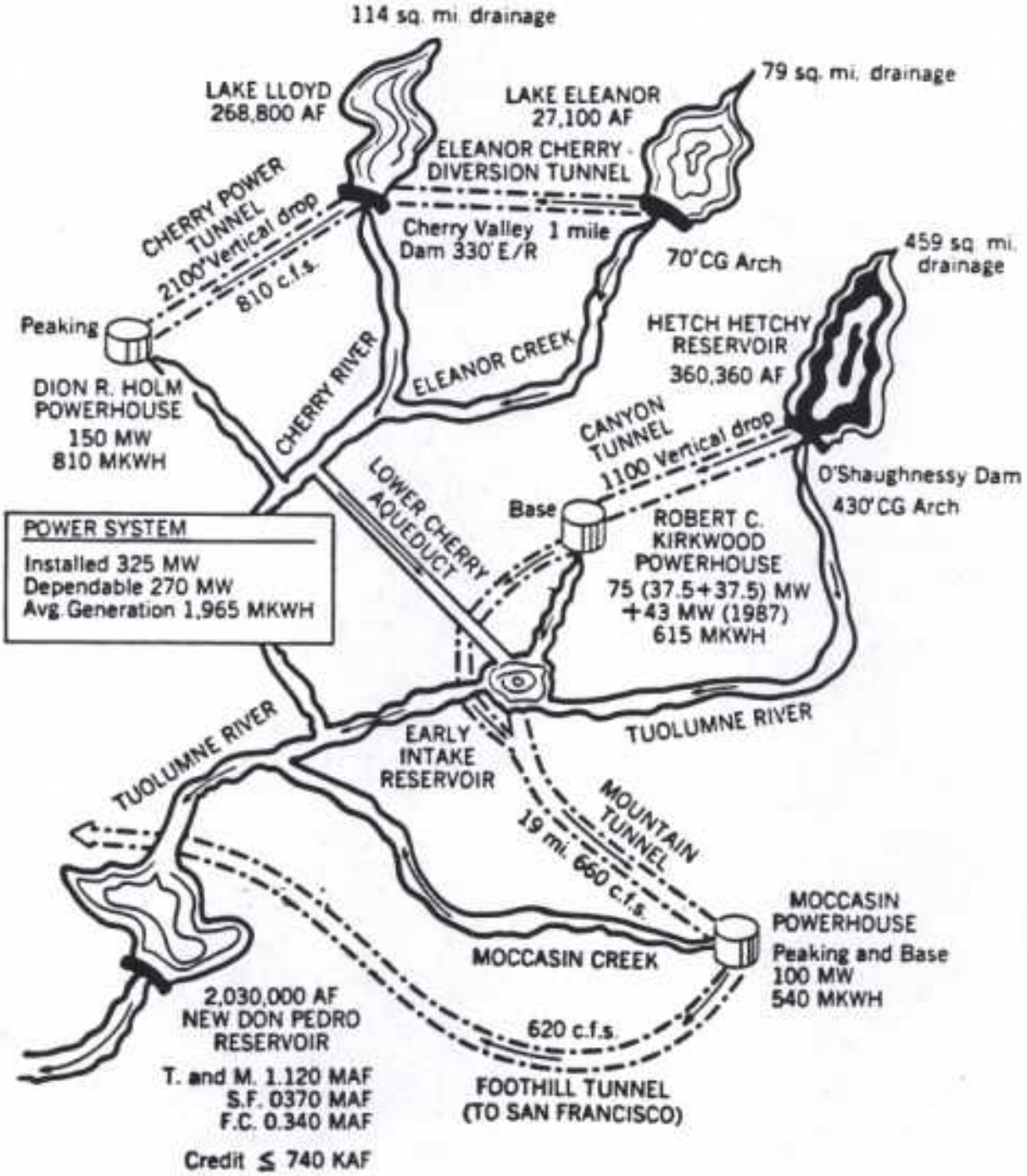
Construction of the Hetch Hetchy System began in 1914. San Francisco financed the project and continues to own and operate the System. The components of the system are described in the sections that follow and are shown graphically in Figure 1.

The Hetch Hetchy Valley is located within the boundaries of the 760,000-acre Yosemite National Park. This park was established by an act of Congress in 1890 and, thus, had already been in existence for over 20 years when the Raker Act was passed. Congress determined that San Francisco's need for a water supply outweighed the conflicting need to preserve the national park in its natural setting. The NPS policy at that time did not preclude such development.

The scenic resources of Hetch Hetchy Valley prior to construction of O'Shaughnessy Dam are said to have rivaled those of Yosemite Valley, about 13 miles to the southeast. Waterfalls, 500 feet high, drop into Hetch Hetchy Valley from the north rim above the dam. Approximately 1,700 acres of flatland formed the valley floor, consisting mainly of meadows with scattered ponderosa pine and California black oak. The valley is about half the size of Yosemite Valley.

Hetch Hetchy Reservoir, in the Hetch Hetchy Valley, is located in the northwest corner of Yosemite National Park and is accessible only by footpath from the trailhead at O'Shaughnessy Dam. It receives relatively little use--only 3 percent of

PROJECT FACILITIES



total park visitation or about 93,400 visits in 1986. Many of the visitors come just to view the dam and reservoir. By comparison, 71 percent of the park visitors saw Yosemite Valley.

The California Wilderness Act, passed by Congress in 1984, placed the Tuolumne River from its headwaters to New Don Pedro Reservoir in the National Wild and Scenic River System. The stretch below O'Shaughnessy Dam is known for the white-water rafting and kayaking opportunities it affords. Further development of the river is restricted by its National Wild and Scenic River designation, but the Wilderness Act preserved all of San Francisco's previous rights under the Raker Act.

2. The Hetch Hetchy Facilities

The Hetch Hetchy System is a set of water storage, water diversion, and electric power generation features that primarily benefit the city of San Francisco and the Modesto and Turlock Irrigation Districts in California. The System consists of three storage reservoirs: Hetch Hetchy (360,360 acre-feet) on the Tuolumne River; Lake Eleanor (27,100 acre-feet) on Eleanor Creek; and Lake Lloyd (268,800 acre-feet) on Cherry Creek. Figure 2 is a map of the Hetch Hetchy System from O'Shaughnessy Dam to San Francisco.

Hetch Hetchy Reservoir is approximately 8 miles long and covers about 1,972 acres. The Reservoir is impounded by O'Shaughnessy Dam. The dam has a crest length of 910 feet, a crest width of 25 feet, and a base width ranging from 298 to 308 feet. It is a concrete gravity arch dam approximately 430 feet high, and containing 674,000 cubic yards of concrete and 760,000 pounds of reinforcing steel. Construction began in 1919 and was completed in 1923. The crest of the dam was raised to its current height in 1938, increasing Hetch Hetchy Reservoir's storage capacity to the present level.

Lake Eleanor Reservoir is situated in Eleanor Valley and is impounded by a 70-foot concrete arch dam. It is also located within the boundaries of Yosemite National Park. Lake Lloyd Reservoir is impounded by the Cherry Valley Dam, an earth and rockfill structure 315 feet in height. Lake Lloyd lies within the Stanislaus National Forest, west of Yosemite National Park. Lake Eleanor and Lake Lloyd are interconnected by the 1-mile-long Eleanor-Cherry Diversion Tunnel and can be operated as a single storage unit.

Water deliveries to the San Francisco area are made via the Foothill Tunnel, whose intake is located at the Moccasin Powerhouse. This 16-mile-long tunnel has a capacity of 620 cubic feet per second (cfs). It delivers water to three San Joaquin Valley pipelines, with a combined capacity of

465 cfs, which convey the water 47 miles further west to the Tesla Portal. From the Tesla Portal, the water moves under the coastal mountains through the 29-mile-long Coastal Range Tunnel (620-cfs capacity) to the Alameda East Portal in Fremont. Here, the Hetch Hetchy System ends and the water becomes the responsibility of the San Francisco Water Department.

Although not a part of the Hetch Hetchy System, the 2,030,000 acre-foot New Don Pedro Reservoir, impounded by New Don Pedro Dam, is operated as an integral part of the System. Jointly owned by San Francisco and the Modesto and Turlock Irrigation Districts, New Don Pedro is located on the Tuolumne River downstream of the Hetch Hetchy System.

Power generation is accomplished through hydroelectric facilities that are physically separated from the reservoirs to maximize elevation differentials and, therefore, hydraulic head. Presently, there are three operating hydroelectric powerplants in the Hetch Hetchy System. The installed capacity of these plants and their average annual energy generation is shown below:

Hetch Hetchy System Power Facilities

Plant Name	Installed Capacity		Average Annual Generation
Holm		150 MW	810 million kWh
Kirkwood	(existing)	75 MW	615 million kWh
	(new)	43 MW	0 (peaking)
Moccasin		100 MW	540 million kWh
Total		368 MW	1,965 million kWh

Based on recent negotiations between the city of San Francisco, Modesto and Turlock Irrigation Districts, and Pacific Gas and Electric Company (PG&E), it was agreed that the firm dependable capacity of the Hetch Hetchy System was no less than 260 MW.

The Holm Powerhouse receives water from Lake Lloyd through the Cherry Power Tunnel, which has a capacity of 810 cfs and a drop of 2100 vertical feet. The Holm Powerhouse is operated as a peaking plant.

The Kirkwood Powerhouse is fed by the Hetch Hetchy Reservoir through the 730-cfs Canyon Tunnel, which has 1100 feet of drop.

The Moccasin Powerhouse receives water from the Early Intake Reservoir on the Tuolumne River through the 19-mile-long, 660-cfs Mountain Tunnel. It can, therefore, draw water from the Hetch Hetchy Reservoir via both Tuolumne River discharges or Kirkwood Powerhouse releases. It is used both as a peaking and a baseload plant. Moccasin discharges are made into the

620-cfs Foothill Tunnel, if required for San Francisco's water supply, or into Moccasin Creek, which returns the water to the Tuolumne River where it eventually flows into the New Don Pedro Reservoir.

3. Operation of the Hetch Hetchy System

Under normal conditions, only Hetch Hetchy Reservoir is operated to supply water directly to San Francisco. Except in dry years, Lakes Eleanor and Lloyd are operated primarily to supply water to the Modesto and Turlock Irrigation Districts and to provide flexibility in the use of Hetch Hetchy for San Francisco water supplies by maintaining streamflows. During droughts and other emergencies, releases from Lake Eleanor or Lake Lloyd can be diverted through the Lower Cherry Aqueduct and into the Mountain Tunnel via the Early Intake Reservoir on the Tuolumne River mainstem. The maximum capacity of this diversion is approximately 100 million gallons per day. All three reservoirs are operated for flood control, instream flow maintenance, and hydroelectric power generation.

The New Don Pedro Dam, Reservoir, and Powerplant are operated by the Modesto and Turlock Irrigation Districts. However, San Francisco owns 570,000 acre-feet of storage space in the New Don Pedro Reservoir. This water is used to help meet the city's obligations to the irrigation districts under the Raker Act. By utilizing the flexibility created by operating New Don Pedro as an integral part of the Hetch Hetchy System, San Francisco can optimize the Hetch Hetchy resources while still meeting its obligations.

There are 340,000 acre-feet in the New Don Pedro Reservoir allocated to flood control. This allocation is practicable because O'Shaughnessy and the other upstream dams and reservoirs exist and are operated as a fully integrated unit. The removal of O'Shaughnessy Dam would, therefore, require a new allocation for flood control in the New Don Pedro Reservoir or in one of the other upstream reservoirs.

The quality of the water supply currently obtained from the Hetch Hetchy System is very high because the point of diversion occurs on an undeveloped watershed with very limited natural degradation.

Very little is known about the nature and amount of sediment buildup in the Hetch Hetchy Reservoir. A sediment survey of the reservoir has not been performed and the DOI report made no projections of sediment accumulation. However, whatever buildup has occurred over the past 65 years would be from a relatively small and rocky watershed. Two extrapolations are possible from this base. The first is that there is a good possibility that the remaining useful life of the dam,

reservoir, and powerplant is considerable. The second is that the nutritional value of the accumulated sediment is likely to be low.

As shown in the table on page 9, the average annual power generation of the Hetch Hetchy System is 1,965 million kWh. About 25 percent of the power generated is used directly by San Francisco. During the last fiscal year, the sale of power generated $89.6 million. Water sales totaled $7.8 million. Operation and maintenance expenses were $70.5 million, leaving $26.9 million in revenues generated by the Hetch Hetchy System for the city of San Francisco.

The three San Joaquin Valley pipelines presently limit the System's water delivery capacity to a maximum of 336,000 acre-feet per year (300 million gallons per day). An upgrading of the System could increase the potential maximum to 448,000 acre-feet per year, or 400 million gallons per day. Over the past 11 years, the city of San Francisco has diverted an average of 214,000 acre-feet per year through the Hetch Hetchy System. This represents 77 percent of the city's total municipal and industrial needs and also includes water delivered to other major suburban areas in San Mateo, Santa Clara, and Alameda Counties. Approximately two million people are supplied by Hetch Hetchy water, which has an average daily yield of 273 million gallons. San Francisco itself uses an average of approximately 96 million gallons of water per day.

B. Department of the Interior Concepts

This section addresses the DOI idea of removing O'Shaughnessy Dam and Hetch Hetchy Reservoir.

1. The Basic Idea

Compared with the complexity in describing Hetch Hetchy, a description of the DOI idea is quite simple. DOI wants to investigate the possibility of removing O'Shaughnessy Dam and draining Hetch Hetchy Reservoir. The presently-inundated Hetch Hetchy Valley would then be reclaimed as a scenic resource for the Yosemite National Park, either through natural means or through active replanting and reclamation efforts. DOI recognizes that the water and power resources presently provided by the Hetch Hetchy System would have to be replaced for this idea to become a truly feasible proposal. The intangible benefits of restoring Hetch Hetchy Valley to its original state have to be balanced against the loss of these water and power resources, the cost and environmental impact of replacing these resources, and the cost and impact of reclaiming the valley once it is drained.

2. Identified Concepts

In its November 1987 draft report entitled Hetch Hetchy: A Survey of Water and Power Replacement Concepts, DOI has provided a summary of the existing situation, and has developed 11 conceptual options for replacing the water and power resources that would be lost with the removal of Hetch Hetchy Reservoir. Water replacement options fall into three general categories: (1) operational changes and/or new development in or related to the Tuolumne River Basin, (2) optimization-coordination-conjunctive uses of surface and ground water supplies, and (3) new supplies from the Sacramento-San Joaquin Basin conveyed by wheeling through the State Aqueduct or by enlarging the Delta-Mendota Canal to the Hetch Hetchy Aqueduct, which crosses both of these conduits. Power replacement options rely on purchases of surplus power and an eventual replacement of the lost capacity through a new generation facility or facilities.

Conceptual water replacement options bank heavily on the ability to reorganize the operation of the Hetch Hetchy System after Hetch Hetchy Reservoir is removed to capture as much of the prior water resource as possible. The first 3 of the 11 options address this reoperation of the System and of New Don Pedro. Options 4 through 10 examine potential supplemental supplies through enlarging other storage structures, constructing new storage, various pumping and conveyance schemes, and conjunctive use possibilities.

S.F. WATER DEPT. CITY RESERVOIRS	
NAME	Capacity Million gallons
LAKE MERCED *	2,565.0
SUNSET	174.0
BALBOA **	150.0
UNIVERSITY MOUND	140.9
SUTRO	31.4
SUMMIT	14.3
COLLEGE HILL	13.5
STANFORD HEIGHTS	12.9
MERCED MANOR	9.5
LOMBARD	3.3
FRANCISCO	2.5
POTRERO	1.0
McLAREN PARK	8.0
HUNTERS POINT	1.1

* EMERGENCY
** PROPOSED

S.F. WATER DEPT. STORAGE RESERVOIRS IN BAY AREA		
NAME	Capacity	
	Acre-feet	Million gallons
CALAVERAS	96,850	31,560
CRYSTAL SPRINGS	69,300	22,580
SAN ANDREAS	19,000	6,190
PILARCITOS	3,100	1,010
SAN ANTONIO	50,500	16,455

ELECTRIC TRANSMISSION LINES					
FROM	TO	MILES	STRUCTURE	CIRCUITS	VOLTS
MOCCASIN P.H.	NEWARK SUB.	98.6	STEEL TOWER	2	115,000
D. R. HOLM P.H.	INTAKE SWYD.	1.6	" "	2	230,000
R.C. KIRKWOOD P.H.	INTAKE SWYD.	0.6	" "	2	
INTAKE SWYD.	WARNERVILLE SUB.	48.4	" "	2	
WARNERVILLE SUB.	SUBSTATION J	12.5	" "	2	115,000

HYDROELECTRIC POWERHOUSES				
	NAME	MOCCASIN	D. R. HOLM	R.C. KIRKWOOD
	COMMENCED OPERATION	1969	1960	1967
	NUMBER OF UNITS	2	2	2
TURBINES	TYPE	MULTI-JET VERTICAL-IMPULSE	MULTI-JET VERTICAL IMPULSE	MULTI-JET VERTICAL IMPULSE
TURBINES	SPEED-RPM	300	400	327
TURBINES	DESIGN HEAD-FEET	1147	2,230	1,245
TURBINES	RATED PLANT H.P.	143,000	187,000	106,000
GENERATORS	RATED PLANT KVA	100,000	150,000	75,000
GENERATORS	RATED POWER FACTOR	0.90	0.90	0.90
GENERATORS	VOLTAGE - KILOVOLTS	13.8	13.8	13.8

HETCH HETCHY RESERVOIRS						
NAME	DAM			CAPACITY		PURPOSE
	TYPE	HEIGHT (FT)	LENGTH (FT)	ACRE-FEET	MILLION GALLONS	
HETCH HETCHY	CONCRETE GRAVITY ARCH	430	910	360,360	117,400	IMPOUNDING
LAKE LLOYD	COMPOSITE EARTH & ROCK	330	2,600	268,800	87,600	IMPOUNDING
LAKE ELEANOR	CONCRETE BUTTRESSED ARCH	70	1,260	27,100	8,830	IMPOUNDING
INTAKE	CONCRETE ARCH	81	262	115	37	DIVERSION
PRIEST	COMPOSITE EARTH & ROCK	160	1,160	1,055	345	REGULATING
MOCCASIN	COMPOSITE EARTH & ROCK	70	855	505	165	REREGULATING

HETCH HETCHY AQUEDUCT - DISTANCES IN MILES O'SHAUGHNESSY DAM TO CRYSTAL SPRINGS RESERVOIR							
POINTS ON LINE	DIVISION	TUNNEL	PIPE	RESERVOIR	CANAL	TOTAL DIVISION	FROM O'SHAUGHNESSY
O'SHAUGHNESSY DAM							0.00
	CANYON	10.64	0.43			11.07	
EARLY INTAKE							11.07
	MOUNTAIN	18.81	0.04			18.85	
PRIEST RESERVOIR							29.92
	MOCCASIN	1.03	1.02	0.57		2.62	
MOCCASIN RES.							32.54
	FOOTHILL	15.85	.45			16.30	
OAKDALE PORTAL							48.84
	SAN JOAQUIN		47.51			47.51	
TESLA PORTAL							96.35
	COAST RANGE	28.64	.59			29.23	
IRVINGTON PORTAL							125.58
	BAY CROSSING		21.24			21.24	
PULGAS E. PORTAL							146.82
	PENINSULA	1.71			0.18	1.89	
CRYSTAL SPRGS. RES.							148.71
TOTAL		76.68	71.28	0.57	0.18	148.71	

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WATER AND POWER SYSTEMS

GENERAL MAP

1983

FIGURE 2

Option 11 deals with the purchase of power to replace the loss of Hetch Hetchy electrical energy. The loss of generation capacity is not fully addressed. The report suggests that only one of the potential water replacement options, an enlarged Shasta Dam and Reservoir, could also represent a replacement of the lost power resource.

III. ISSUES AND CONCERNS

The issues and concerns identified from an analysis of the Hetch Hetchy concept and the draft DOI report basically address the validity of the concept itself. They center upon the overall general costs, both dollar and environmental, versus benefits that would be associated with the idea should it become reality. Although many of the costs/benefits cannot be accurately quantified because of the preliminary nature of the concept, the idea raises serious concerns about its feasibility even at this early stage.

In addition, there are issues and concerns associated with the options identified in the draft DOI report. Here, the issues and concerns are more defined and specific, and address the viability of the identified concepts to replace the lost water and power resources.

The issues and concerns that arise from the draft DOI report and the general concept of draining Hetch Hetchy Valley can be grouped into four categories. These categories are the loss of generation capacity, the loss of water storage capability, the environmental ramifications, and the economic costs. The issues and concerns that are identified with each of these four areas are detailed in the remainder of this section.

A. Power Issues

Under conditions where the power resources and the power demands of a power supply area are in balance, any proposal or plan that would cause a change in that balance would incur the cost of restoring that balance. Also, under such conditions, it is relatively easy to assign cost and assess impacts. However, when there is an imbalance in the power supply equation, such as currently existing in California (current power resource projections show capacity surpluses through the year 2000), the full impact of a proposed change in certain power resources will not be realized until a power resource balance is reached. Given this condition, a discussion of the potential impacts of the DOI concept on power resources in the northern California area is presented below.

The DOI proposal for restoring Hetch Hetchy Valley by removing O'Shaughnessy Dam would cause a reduction in existing power resources.

1. Energy Loss

If O'Shaughnessy Dam is removed, the energy generation at the Kirkwood plant would be reduced from 615 million kWh to zero. In addition, energy generation at the Moccasin plant would be reduced because of the unregulated inflow of the Tuolumne River. Moccasin's reduction is conservatively estimated to be around 300 million kWh. Thus, the net amount of energy loss is assumed, in the DOI report, to be 900 million kWh. Some increase in the long-term average generation at the New Don Pedro Powerplant could also be experienced because of reduced upstream diversions, however, this increase could be negated by a requirement that the New Don Pedro Reservoir carry more capacity as flood storage. This amount of energy loss is conservative, and it does not reflect any additional losses that may occur at Holm Powerplant by reoperation of the Hetch Hetchy System, as suggested in the DOI report.

2. Capacity Loss

Because the Kirkwood plant operates as base load, its loss would have a significant impact on the dependable capacity of the Hetch Hetchy System. Furthermore, the amount of firming support for the remaining hydroelectric plants would also increase. As a result, the actual reduction in dependable capacity would be determined from negotiations. For purposes of evaluation, the 150 MW estimate made in the DOI report is considered reasonable and is used in this evaluation.

3. Substitute Resources

The resources that may be available to offset the loss of 150 MW of capacity and 900 million kWh of energy will depend on when the proposal is implemented. Until the year 2000, there is sufficient surplus capacity in California and the Western Systems Coordinating Council interconnected power supply area to replace this loss. (See Appendices 2, 3, and 4.) Due to the existence of this surplus, the full impact of this firm power loss will not be realized until the year 2000 or later. The availability of this surplus capacity, however, does not offset the loss in energy. The effect of the loss of 900 million kWh of clean hydroelectric energy will result in the immediate increase in the use of the most expensive and least desirable fuel sources. Since California relies primarily on oil and natural gas for energy generation, the lost energy will likely result in the annual consumption of an additional 1.7 million barrels of oil. At $20 per barrel, the additional cost comes to $34 million annually.

By the mid-1990's, when electric demands and supplies are nearing balanced conditions, the loss of 150 MW of dependable capacity at Hetch Hetchy would have to be replaced either through conservation or by the addition of a new plant or plants. Therefore, the effects of the capacity loss should be measured in terms of replacement costs, which are estimated to be $46 million annually.

4. Other Potential Losses

As previously stated, the power losses of 150 MW of firm dependable capacity and 900 million kWh of energy do not include potential losses in power that may occur at the Holm Plant if the Hetch Hetchy System is reoperated, as discussed in the DOI report. Nor does this power loss reflect any of the additional pumping power that would be required in several of the alternatives presented in the DOI report for the recapture of the water supply. The total extent of the power losses could be such that the total dependable capacity of the Hetch Hetchy System (260 MW) could be eliminated. The figures of 150 MW and 900 million kWh should, therefore, be treated as very conservative and a minimum impact situation.

At the time when a resource balance is reached and a replacement resource is required to offset the Hetch Hetchy power losses, the alternative replacement costs would be:

- Initially - $25.5/kW-month for capacity and 38 mills/kWh for energy

- Levelized - $25.5/kW-month for capacity and 70 mills/kWh for energy

Thus the total annual cost associated with the DOI concept would be $80 million initially and $109 million when levelized over the life of the plant.

B. Water Issues

A major issue concerning the restoration of the Hetch Hetchy Valley by the removal of O'Shaughnessy Dam is the loss of a developed, high-quality water supply. The State of California, Department of Water Resources, Bulletin 160-87, is currently predicting that net annual water use in California will increase by 1.4 million acre-feet (MAF) in the next 25 years. (See Appendix 5.) This increase in net water use is based on projected population growth. Appendix 6 shows known and expected population expansion for California to the year 2010, indicating an increase of 39 percent. Of this total increase, the San Francisco Bay and Central Coast Region accounts for 0.2 MAF, and another 0.58 MAF is allocated to the San Joaquin River and Tulare Lake Region. Meeting the total increase in net water use assumes the development of a number of new water supply facilities to complement the existing water supply facilities, one of which is the Hetch Hetchy System.

Hetch Hetchy Reservoir alone has a reported average daily yield of 273 million gallons (or 99.6 billion gallons annually). Removal of this reservoir amounts to an annual loss of 0.30 MAF (1 acre-foot equals 326,000 gallons) to the San Francisco Bay Region. The Hetch Hetchy System has provided an average of 0.214 MAF annually during the 11-year period July 1978 through June 1986 to the city of San Francisco and the San Francisco Bay area. Maximum annual delivery capability is 0.336 MAF with the existing conveyance capacity. Maximum potential annual delivery capability is 0.448 MAF with upgraded conveyance facilities in the San Joaquin Valley.

The Modesto and Turlock Irrigation Districts' New Don Pedro Reservoir was designed to operate as an integral part of the Hetch Hetchy System. Hetch Hetchy Reservoir storage is integrated into the flood control operation of New Don Pedro Reservoir. Under current operations, the New Don Pedro Reservoir flood control requirement can be reduced by up to 80 percent of the available space in Hetch Hetchy and Cherry Valley Reservoirs. This type of coordinated operation helps to maximize New Don Pedro power and water production by providing some control over the peak flows. Removal of the Hetch Hetchy Reservoir would increase the requirement for flood space at New Don Pedro Reservoir, thereby requiring reduced reservoir levels with a potential loss of power production and water yield.

Removal of part of the Hetch Hetchy System will not only affect the water supply to the San Francisco Bay Region, but will also affect the water supply to the Modesto and Turlock Irrigation Districts in the San Joaquin River Region. No estimate of loss is available for the San Joaquin River Region.

Replacement alternatives will most likely involve the development of new points of diversion below the existing points on the Tuolumne River and new diversion points on different watersheds. New diversion points will most likely result in lower quality water supplies, due to either natural conditions in the drainage or manmade developments. If water supplies near the Sacramento-San Joaquin Delta are used, the loss in quality will be very significant.

C. Environmental Issues

1. Introduction

The basic issue from the environmental perspective is the trade-off in environmental values that would be necessary to achieve the restoration of Hetch Hetchy Valley. Serious environmental impacts would result from draining the reservoir and removal of the dam. The existing situation must be considered the baseline for comparison and, by definition, one of zero impact. The System has been in place and operating for over half a century, so any departure from the present situation must be examined in light of the benefits and impacts which would result from implementation of that action. Appendix 8 contains some pertinent excerpts from the 1980 General Management Plan for Yosemite National Park.

In addition, the options for replacing the lost water and hydropower generation resources have the potential for significant environmental impacts, some possibly quite severe. These effects must be added to those related to the removal of O'Shaughnessy Dam and evaluated against the benefits of restoring Hetch Hetchy Valley.

The stated benefit of removing Hetch Hetchy Reservoir is the restoration of Hetch Hetchy Valley to its former state. To quote from the draft DOI report, "Positive impacts...would evolve around the long-term environmental and public trust benefits associated with the restoration of the site to its natural condition.... Such restoration would renew the national commitment to maintaining the integrity of the national park system and keep in perpetual conservation an irreplaceable and unique natural area." According to the report, "Terrestrial and aquatic benefits would accrue to recreation, aesthetics, and the overall area ecology. To the extent that water that would otherwise be diverted remains in the system..., the removal of O'Shaughnessy Dam could have potential for positive impacts to the San Joaquin River and estuarine ecosystems."

It is difficult to assign a value to the proposed restoration of Hetch Hetchy Valley. Unlike many concepts, this idea does not place development against the environment. Instead, it involves the substitution of one set of environmental values for another set of different environmental values, both of which are mostly intangible in nature. On the surface, the concept is one of those noble ideas that seem like the right thing to do. A reasoned analysis of the idea, however, shows it to be less attractive than the initial reaction might suggest.

DOI has stated that the restoration of Hetch Hetchy Valley could reduce the pressure on Yosemite Valley by redistributing visitors, thereby benefiting Yosemite National Park. At present, approximately 3 percent of the Park's visitors (about 93,400 in 1986) visit the Hetch Hetchy area. Many of these present visitors come to Hetch Hetchy just to view the dam and reservoir. This low percent of visitation is due, in part, to the fact that access past the O'Shaughnessy Dam is limited to footpath only. DOE is aware of no plans to improve access to Hetch Hetchy Valley should it be restored. With the reservoir in place, Hetch Hetchy presently offers diversity to scenic and recreational opportunities. It adds a water-based visual and recreational resource to a park primarily directed towards terrestrial scenic values.

If the NPS was actively seeking opportunities to lessen the usage of Yosemite Valley, it could promote the use of the Hetch Hetchy Reservoir as an alternative recreational site and experience. A second, smaller version of the Yosemite Valley, having limited access, may not have the ability to attract additional visitors away from the more famous and spectacular site. In short, the concept does not appear to have the means to significantly reduce visitor pressure on Yosemite Valley or to provide a greatly enhanced recreational opportunity for those visitors who presently use the area. At the same time, draining Hetch Hetchy would reduce the diversity of recreation opportunities available within the park. It can be argued that the existing water resource as a National Park asset is more valuable than the restored meadow resource would be.

The identified primary "benefit" to be derived from the restoration of Hetch Hetchy is the conversion of 1,972 acres of surface water to an equal expanse of meadows and scattered trees, and certain unspecified "benefits" to terrestrial and aquatic ecology. What the ultimate potential environmental cost of this undertaking would be, and how it would compare to any identified gain, is not known. Insufficient data are available to quantify environmental costs and impacts in detail. However, specific issues and concerns can be identified and, in some cases, a magnitude of impact ascertained. Economic aspects are addressed in the economics section of this document; this discussion is limited to an examination of potential environmental impacts.

2. Issues and Concerns Related to Facility Removal

The release of the stored water could presumably be accomplished with little environmental impact, assuming it was done slowly. The reservoir fishery resource would be lost, as would valuable riparian habitat, particularly at the upstream end of the reservoir. This riparian habitat would be replaced eventually but, in the interim, wildlife populations could

suffer from the loss and both terrestrial and aquatic ecology in the area would be drastically altered. Wildlife species which prefer open water, for example waterfowl, would lose a valuable habitat area. Species that utilize meadow habitats would eventually experience an increase in their habitat as the valley revegetated.

The removal of the Hetch Hetchy facilities would create environmental effects related to downstream ecosystems in the form of stream turbidity and sedimentation. The duration and magnitude of such impacts would depend on the success of mitigation during demolition activities, and the success of reclamation after demolition activities have been completed. Streamflows from Hetch Hetchy to New Don Pedro would be affected, and potential impacts to fish and stream ecology would need to be identified and assessed. The DOI report indicates that recreation and ecology would benefit from these changes. Without further study, it can already be concluded that kayaking and whitewater rafting recreation activities could be significantly impacted due to a return to unregulated river flows. The effect would be aggravated during drier water years. Erosion of the unvegetated drained valley bottom could result in serious siltation problems in the Tuolumne River, affecting water quality for fish and other aquatic species and the water supply for San Francisco and the other areas which use Hetch Hetchy water. Any additional water in the river would be present when flows are high; low flows are likely to be lower without Hetch Hetchy storage to provide minimum flow releases. The draft DOI report's claim of environmental benefits would not seem to be supported.

Proposed demolition and removal of the subject facilities would also result in fewer fishing, camping, and backpacking visitor use days in the area of the reservoir. Reduced short-term recreation uses in the Hetch Hetchy Valley would be associated with extreme noise levels (70 to 90 db), increased fugitive dust problems, and the highly instrusive nature of earth-moving machinery within a secluded national park.

The removal of O'Shaughnessy Dam and Hetch Hetchy Reservoir may also result in legal problems. Such an action might conflict with the California Wilderness Act and the National Wild and Scenic River designation that applies to the Tuolumne above New Don Pedro. San Francisco and the irrigation districts also retain Congressionally-granted rights under the Federal Raker Act which would be impacted should the concept be developed against their wishes. The potential exists for legal problems related to the appropriation of water from sources other than the Tuolumne.

Another consideration is that O'Shaughnessy Dam may well be eligible for inclusion on the National Register of Historic

Places. It is not known if the Dam has been nominated at this time but, before any removal scheme is contemplated, its historical significance would have to be assessed under the National Historic Preservation Act of 1966.

The physical removal of O'Shaughnessy Dam and related facilities would, without question, result in very serious environmental impact. Additional roads might have to be constructed into the site. The destruction of the dam would be disruptive to recreationists and wildlife in the area during the time of dismantling. The dam contains approximately 674,000 cubic yards of concrete and 760,000 pounds of reinforcing steel, all of which would have to be removed from the site and disposed. The disposal area or areas for this material would be severely impacted environmentally. Transportation routes between the dam site and the selected disposal areas would experience heavy traffic and potential damage during the demolition process. The former reservoir bottom and dam site, the road system, and the disposal area or areas would all require extensive reclamation (e.g., regrading, seeding, and erosion protection) to minimize environmental impacts.

An alternative not discussed in the DOI report is that of draining the Hetch Hetchy Reservoir, but leaving O'Shaughnessy Dam in place. This option would minimize negative environmental impact and costs by eliminating those costs and impacts related to the physical destruction and disposal of the dam itself. However, it is doubtful that this would be a seriously considered elective. Recovery of the natural and scenic values of Hetch Hetchy is the stated goal of the concept, and the dam would severely affect these values if left in place.

3. Issues and Concerns Related to Water Replacement

The DOI report indicates that "reoperation" of the remaining Hetch Hetchy facilities and New Don Pedro could recoup all of the water presently diverted for the existing water users and much of the present potential maximum the System could produce. However, the report is very unclear as to how this reoperation would occur. It appears that a minimum of 100,000 acre-feet per year could be directly diverted into the gravity system for delivery to San Francisco. Utilization of additional Tuolumne River water would probably require the enlargement of existing reservoirs or the construction of new ones, new conduits for water transport, and pumping facilities.

It is clear that both substantial modification to the present operations of existing facilities and physical modifications to those facilities, and construction of new facilities, would be necessary to accomplish any water supply replacement

objective. Modifications to operations represent a change that has the potential for significant environmental effects through changed streamflows, reservoir level fluctuations, and water quality. Physical modifications or new construction will result in new environmental impacts in new areas that would have to be offset by benefits accrued from a reclaimed Hetch Hetchy Valley. Details are lacking to speculate on the severity of such impacts, but in general inundation and/or major construction when imposed on an existing environment creates severe impact.

The DOI report gives a series of options (4-10) which consider supplemental water supplies to make up any shortfall from the first three options, which recover Hetch Hetchy water from the Tuolumne. Most, if not all, of these conceptual options would involve new construction with an attendant environmental impact. In addition, most are net energy consumers due to the necessity for pumping, thus exacerbating the loss of hydrogeneration capacity discussed earlier in this report. Secondary environmental effects would be associated with replacing the energy required for this pumping, which is essentially a new consumptive use required by the implementation of the concept. A third issue relates to the use of water from other sources to make up for lost Hetch Hetchy water. The water may in fact be available, but it is not a "new' source. Taking water from these other sources will make it unavailable in the future for other uses or to other entities. It is, therefore, properly viewed as "lost" water or an impact for purposes of analyzing the cost/benefit of the Hetch Hetchy restoration idea. California will eventually need to maximize all of its water supplies, so any loss of Tuolumne water represents a true loss.

A final issue regarding water replacement is the one of water quality. The water presently supplied by Hetch Hetchy Reservoir is of extremely high quality, coming as it does directly from high mountain snowmelt in a relatively small and pristine basin. All other proposed replacement options would provide water significantly less pure than the present supply. Besides the human health and aesthetics aspects, there is the possibility that the less pure replacement water supplies would require modifications to present treatment facilities or even new facilities. The costs of such modifications or new water treatment facilities would be directly attributable to the implementation of the Hetch Hetchy concept.

4. Issues and Concerns Related to Power Replacement

The potential effects of the Hetch Hetchy concept on power generation and supplies were discussed earlier in this report. Essentially, a minimum of 150 MW of firm capacity and

900 million kWh of energy would be lost; more could be lost depending on how Lakes Eleanor and Lloyd are reoperated to make up water losses.

In addition, most of the other water replacement options are net energy consumers; the power for those options ultimately selected would also have to be replaced. In any case, the total loss in capacity and energy would have to be made up, most likely in the form of a new oil or natural gas-fired thermal powerplant.

The construction, operation, and maintenance of a thermal powerplant of at least 150 MW capacity would have significant environmental impacts. Issues raised would include, but not be limited to: consumption of nonrenewable resources in place of a renewable one, air pollution, acid rain, thermal pollution of water resources, water consumption for cooling purposes, and visual and land use impacts from the plant and associated transmission facilities. These potential impacts would be directly attributable to the implementation of the Hetch Hetchy concept and would have to be weighed against the benefit resulting from the restoration of Hetch Hetchy Valley.

Purchases of available surplus power for short-term replacement of the lost capacity and energy would probably not result in significant environmental impact, as these purchases would come from installed capacity and be delivered over an existing transmission system. However, this is not a viable long-term solution, as discussed in Section III.A.3.

5. Summary of Environmental Issues and Concerns

A careful examination of DOI's Hetch Hetchy idea reveals that the concept will cause significant negative environmental impact. The "public trust benefits" alluded to in the DOI report do exist as intangibles. However, the Hetch Hetchy area receives relatively light visitor use at present, a situation that is not expected to change greatly with the restoration of the valley. The water resource represented by Hetch Hetchy Reservoir may not be less of a visual and recreational resource to some individuals than the restored valley would be. During the years it would take to revegetate and reclaim the former reservoir, the area would certainly be negatively impacted from the perspective of visitors.

The DOI report claims benefits to recreation, aesthetics, and terrestrial and aquatic ecology. Although recreation and aesthetic values would change in focus from water-based to terrestrial-based, the report fails to make a case that the restored valley would have greater overall values than it does presently. Such values can be significantly affected by how the NPS chooses to manage the Hetch Hetchy Valley. Under the

existing management plan, the NPS is clearly taking a preservation course with minimal development of Yosemite resources. Given this stance, it appears to matter little if Hetch Hetchy Valley contains meadows or a reservoir. It is known that kayaking and white-water rafting on the Tuolumne downstream of Hetch Hetchy would be negatively impacted by the removal of the dam.

It is unclear why DOI believes both terrestrial and aquatic ecology would benefit from the restoration concept. Implementation of the restoration idea would severely disrupt an existing environmental system that long ago adjusted to the presence of the dam and reservoir. The aquatic ecology of the reservoir would be destroyed, and a replacement stream-based ecology would be slow to develop. Potential siltation problems from erosion of the former reservoir could adversely affect the existing downstream ecology, as could dam demolition activities. Streamflows would also change with the removal of Hetch Hetchy Reservoir. As with recreation and scenic values, terrestrial and aquatic ecologies would experience a shift as a result of the concept, but the tradeoffs involved make it difficult to determine that the restored valley would be a significant improvement over the existing situation. Area ecology would certainly be negatively affected over a lengthy period of time until it could adjust to the new conditions, and revegetation and reclamation were completed.

The foregoing portion of the environmental summary has dealt only with issues localized to the Hetch Hetchy area. The restoration concept finds little support at this level when ostensible benefits are compared to probable negative environmental impacts. The idea loses any remaining validity when the environmental effects related to actions taken to replace water and power generation losses are added to the balance. These negative impacts would occur as a result of water storage expansion or construction, streamflow changes and reservoir fluctuations related to Hetch Hetchy reoperation and/or conjunctive use arrangements, the construction of new water conduits or relocation of hydrogeneration facilities, increased energy use from new pumping loads, and a multitude of other factors.

From the environmental perspective, the idea of restoring Hetch Hetchy Valley, while initially intriguing and idealistically laudable, does not promise future benefits commensurate with the environmental impacts that would result. Even a brief analysis, such as this document contains, is sufficient to determine that the basic concept is not viable environmentally. There will be those individuals who feel that the intangible benefits of a restored Hetch Hetchy Valley are

worth the cost no matter how high. The approach that has been taken in this analysis considers what the average person's values might be. Hetch Hetchy Valley might be restored, given time, to a condition near what it was at the turn of the century. However, the cost in environmental impact, both to the Hetch Hetchy area and to the many other areas that would be impacted in order to supplant lost water and power resources, is too high.

D. Economic Issues

The Hetch Hetchy System presently has a total electrical generating capability of 368 MW. The dependable capacity associated with this capability is 260 MW which comes from the Holm, Kirkwood, and Moccasin Powerhouses. The respective capacity associated with each facility is 150 MW, 118 MW, and 100 MW. The recent 43 MW addition to the System at Kirkwood is assumed to add no additional energy. The 43 MW addition to Kirkwood also did not change the 260 MW dependable capacity figure.

The Hetch Hetchy System average annual generation is 1,965 million kWh and consequently has a system plant factor of 61 percent. The Kirkwood unit provides 615 million kWh, resulting in a plant factor of 59 percent. Moccasin Powerhouse generates 549 million kWh and results in a plant factor of 62 percent. The Holm unit also has a 62 percent plant factor, but has generation of 810 million kWh.

It is estimated that the dismantling of the O'Shaughnessy Dam would remove at least 150 MW of the dependable capacity from the total system capability of 260 MW. With the assumption that a change in dependable capacity is proportional to a change in installed capacity, it can be inferred that the reduction of System capacity would be approximately 205 MW. The greatest impact, of course, comes from the removal of Kirkwood Powerhouse. The bulk of the remaining losses are attributed to the impact of changed operations on Moccasin Powerhouse with possible slight losses from the Holm peaking unit.

The lost generation from the entire System due to the removal of Kirkwood Powerhouse, together with the operating changes, is estimated to average 900 million kWh annually. This represents just under half of current System output at a plant factor of between 50 to 68 percent, depending on whether installed capability or dependable capacity is used.

There have been no forecasts as to when the removal of the O'Shaughnessy Dam would take place nor when replacement power supplies would be required. It seems likely that the mid-to-late 1990's would mark the beginning of such activity. If this is the case, then surplus capacity in northern California is likely to be declining or eliminated. Hence, the construction of new capacity would be required to replace the O'Shaughnessy decommissioning and attendant loss of Hetch Hetchy generation capacity. Forecasts of plant utilization on the West Coast indicate that capacity will be more completely used at that time than today.

The generation lost by removing the Kirkwood Powerhouse and modifying operations most nearly resembles the operation of a baseload thermal plant. The present value of the installed

capacity of a baseload plant brought on line in the mid-1990's is estimated to be about $1700/kW in 1987 dollars. This would yield a capacity charge of approximately $25.5/kW-month for a plant with a 30-year life. It is likely the thermal plant would need to be replaced in order to match the remaining life of the hydro facility for the purpose of comparing lifetime impacts of the two options. Additional replacements of thermal facilities would make the thermal replacement relatively more costly than continued use of the hydro facility because of the pressures of inflation on the thermal facility. Assuming for the moment that the baseload plant replacing the hydro facility burns residual oil, the average energy cost for the life of the plant will be approximately 70 mills. If the lost capacity is 150 MW, then the cost just to replace the lost power with a newly-constructed thermal facility would average approximately $109 million per year over a 30-year period. By comparison, current estimates of San Francisco's annual operation and capital costs for Hetch Hetchy are $39-$59 million, but this estimate includes water costs.

Power Replacement Costs

Period	Current Cost of Capital and Operations to San Francisco	Energy Costs Without Kirkwood	Alternate Plant
1987-1995	$39-$59 million/yr*	$34-$41 million/yr	-------
1995+	$39-$59 million/yr*	$63 million/yr (for alternate plant)	$109 million/yr (capacity and energy)

*Includes water costs

The city of San Francisco is currently in the process of renewing its power wheeling contracts with PG&E, due to the recent expiration of existing agreements. Appendix 7 shows a recent city financial comparison of expenditures and revenues that can be expected from the new contracts.

The economic costs of demolishing the O'Shaughnessy Dam are difficult to estimate without specific information regarding the method and schedule for removal, the number of workers potentially involved, and a host of on-site logistical problems. Relatively little precedent exists for the decommissioning and removal of such a large scale hydroelectric project. Indeed, it is understood from informal contacts with the Federal Energy Regulatory Commission and the U.S. Army Corps of Engineers that hydroelectric facilities that have become obsolete or unuseful for a variety of reasons are typically not removed, but simply

abandoned. Without further study, it is nonetheless clear from available data that removal of O'Shaughnessy Dam would be very expensive, perhaps in excess of several hundred million dollars.

In demolishing this dam and reservoir, a number of secondary costs would also be realized. A number of wide-haul roads would likely have to be constructed to remove the approximately 674,000 cubic yards of concrete and other associated dam materials. It is further assumed that mitigation of on-site environmental problems would be significant and costly. For example, it may be environmentally desirable or necessary to remove much of the accumulated silt from the reservoir site. Additional associated expenses, depending upon the findings of environmental studies, could include an extensive revegetation program to minimize downstream siltation impacts and long-term visual effects. Further, it may be necessary to rechannelize the river below O'Shaughnessy Dam, at considerable expense, in order to ensure complete restoration of the valley to preconstruction conditions.

The economic costs of providing replacement water for the city of San Francisco, the Modesto and Turlock Irrigation Districts, and Tuolumne instream uses is highly speculative at this time. These costs are dependent on the amount of water that can be salvaged from the remaining facilities on the Tuolumne River and the option selected for supplying the remaining requirement. The majority of the options identified for providing replacement water require the modification of existing, and/or development of new, water storage facilities, conveyance facilities, and water treatment facilities. DOI rates the costs of these options from low to extremely high. In addition to structural facilities, these replacement options will require pumping of the replacement water. The actual amount of energy and capacity required and cost are again dependent on the amount and source of the replacement water. It is conceivable that the pumping load could require the addition of new generation. Some entities in the area have estimated the total replacement costs from $2-6 billion, but DOE can neither verify nor deny those figures.

IV. CONCLUSIONS

From the information and findings in Section IV, it is concluded that the concept of reclaiming Hetch Hetchy Valley by draining Hetch Hetchy Reservoir and removing O'Shaughnessy Dam is presently not viable. The idea itself is bold, and the goals are without question meritorious. However, the concept must be viewed in light of its potential cost. In essence, the concept involves the replacement of existing valuable resources with another group of resources, also valuable, that differ from the present ones. From the average individual's perspective, the anticipated total resource values of the reclaimed Hetch Hetchy Valley do not appear to be substantially higher than those that presently exist, and the conversion can only be accomplished at great economic and environmental cost. The costs and consequences of removal of a presently beneficial, vital high-quality water supply facility are clearly too great compared with the benefits a rehabilitated Hetch Hetchy Valley would provide.

From the energy perspective, the replacement of at least 150 MW of lost hydropower capacity with an equivalent thermal generation plant or plants, clearly represents a large negative impact. An existing, clean, inexpensive, renewable resource would eventually be exchanged for a more expensive, nonrenewable resource. Existing amounts of surplus energy are already a more costly alternative.

Only a portion of the present potential maximum water diversion could be recovered from a reoperated Hetch Hetchy System. The shortfall could be made up through enlarged or new reservoirs, new conveyance systems, and other major construction projects, but all of these measures would be extremely expensive and cause significant environmental impact to new areas away from Hetch Hetchy. The existing operating system meets the needs of the participants for a high-quality, dependable water supply at minimal cost. There is no assurance that the replacement options will provide equal dependability or quality. Hetch Hetchy also provides the means, with some modification to the conveyance system, to meet future demands up to 448,000 acre-feet per year. This potential maximum would have to be fully replaced in order to calculate the total cost of removing Hetch Hetchy Reservoir.

Water obtained from sources other than the Tuolumne would not be available for future development by potential users. In addition, many of the water replacement options are net users of energy due to pumping requirements. These, too, are considerations which must be weighed against the concept of restoring Hetch Hetchy Valley. The replacement water supply schemes provide no assurances that the current high quality water supply realized from the O'Shaughnessy facility could be maintained.

Environmentally, the idea creates far more potential for significant impact than can be justified by any incremental benefits from

restoring Hetch Hetchy Valley. An examination of the potential benefits to be gained from a restored Hetch Hetchy Valley shows many of them to be converted from existing values which would be lost. Removing O'Shaughnessy Dam and draining the reservoir will result in significant environmental impact alone. The effects of physically demolishing and removing the dam are substantial, and the debris will have to be transported and disposed, adding further significant negative environmental impact. The dam could simply be decommissioned and left in place, thereby significantly reducing economic costs and direct physical environmental impact, however, much of the anticipated gain in intangible wilderness values would be negated by the continued presence of O'Shaughnessy Dam. When the impacts associated with the implementation of some of the replacement options are added, it becomes clear that potential negative effects would greatly outweigh potential positive benefits.

Perhaps the economic costs of the concept are the most convincing argument against further consideration or implementation of the idea at this time. Virtually every aspect discussed under the water section, the power section, and the environmental section has costs associated with it. These are all new costs, as the only costs related to the present System are operation and maintenance expenses and some capital repayment costs. Although it would be impossible to accurately estimate a total cost for implementing the idea at this time, the cost would certainly be extremely high and would have to be borne almost entirely by the Federal Government.

There would be no incentive for the city of San Francisco or the irrigation districts to share in the cost; they currently have an operating system that provides for their present needs with considerable potential for further development. The action proposed by the Federal Government would deprive them of some of the resources their system generates, so they rightfully would be looking to the Federal Government to replace these resources in kind and at no cost.

V. RECOMMENDATION

A careful evaluation of the idea of restoring Hetch Hetchy Valley as conceptualized in the DOI Hetch Hetchy report resulted in a number of conclusions, presented in the preceding section. The following is DOE's recommendation with respect to the Hetch Hetchy Valley recovery concept.

DOE proposes that the idea of restoring the Hetch Hetchy Valley be revisited in the future at the point in time when O'Shaughnessy Dam is reaching the end of its useful life (typical design life of similar facilities is 100 years). DOE recognizes the value in reassessing an existing facility in light of changed national values. Certainly there was interest in preserving Hetch Hetchy Valley in its original state when the System was first proposed, and there is presently heightened interest in public land preservation. The impacts of removing the dam, both economic and environmental, become a necessity, not an option, when the dam reaches the end of its useful life.

Postponing any action until the dam reaches the end of its useful life has a number of significant advantages. The city of San Francisco will be faced with a necessary shift in their water supply system and will likely have already made water replacement arrangements in anticipation of the loss of O'Shaughnessy Dam and Hetch Hetchy Reservoir. It will be possible to accomplish these water replacement projects as part of a comprehensive long-term development plan, instead of as a response to a sudden removal of a key facility in the System. The Federal Government may avoid many of the costs of water replacement and dam removal, as it will not be the causal agent for the loss of Hetch Hetchy.

Environmental impacts of developing water and power supplies to replace Hetch Hetchy resources, although they may occur, would not be assigned to the restoration of Hetch Hetchy Valley under this scenario. Similarly, the costs of removal, major renovation, or replacement of the dam would be a requirement at that time and would not have to be considered against the benefits of a reclaimed valley. Therefore, a cost/benefit analysis of the concept would be much more favorable to the idea in the future than at present. It is also possible that advances in technology could have a significant effect on the overall situation by that point in time, although it is impossible to speculate what form they might take. To obtain a better idea of the dam and reservoir's remaining useful life, a thorough inspection of O'Shaughnessy Dam and a preliminary reservoir sediment survey could be undertaken.

DOE's present opposition to the Hetch Hetchy restoration concept is based primarily on the very high economic and environmental costs that are associated with its implementation. These high costs are implicit both in the removal of the dam and restoration of the valley and in the water and power replacement options. Clearly these costs outweigh

the potential benefits at this time. However, our analysis concludes that the costs assigned to these components will decline greatly as the dam ages. As the dam reaches the end of its useful life, the idea of restoring the Hetch Hetchy Valley should once again be examined.

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